UXO & GIS

Using GIS/GPS to manage, model, and analyze Unexploded Ordnance (UXO) data gathered at Limestone Hills TA, Montana

Rory Ruffner
GIS Specialist
Montana ARNG Environmental Program
Helena, Montana

Background

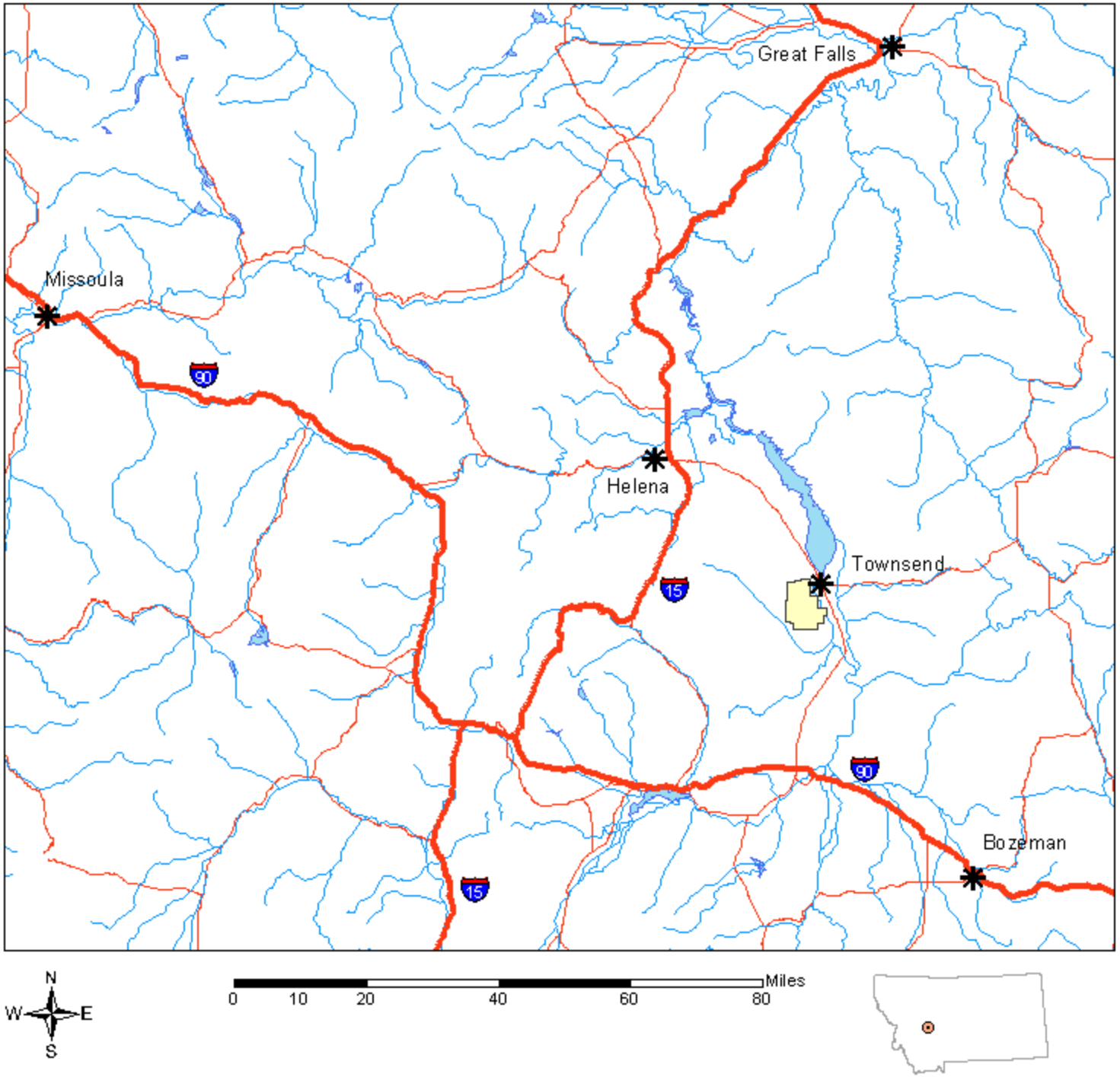
- Live round fire beginning in 1950’s
- Possible groundwater contamination
- Graymont Western Mine
- PUBLIC SAFETY!!!

Timeline

- First studies done by MTARNG in early 1990’s
- Studies have been ongoing over past summers
- Projected end date: Report due to DoD is in progress.
  - DoD makes final decision about further mining activities

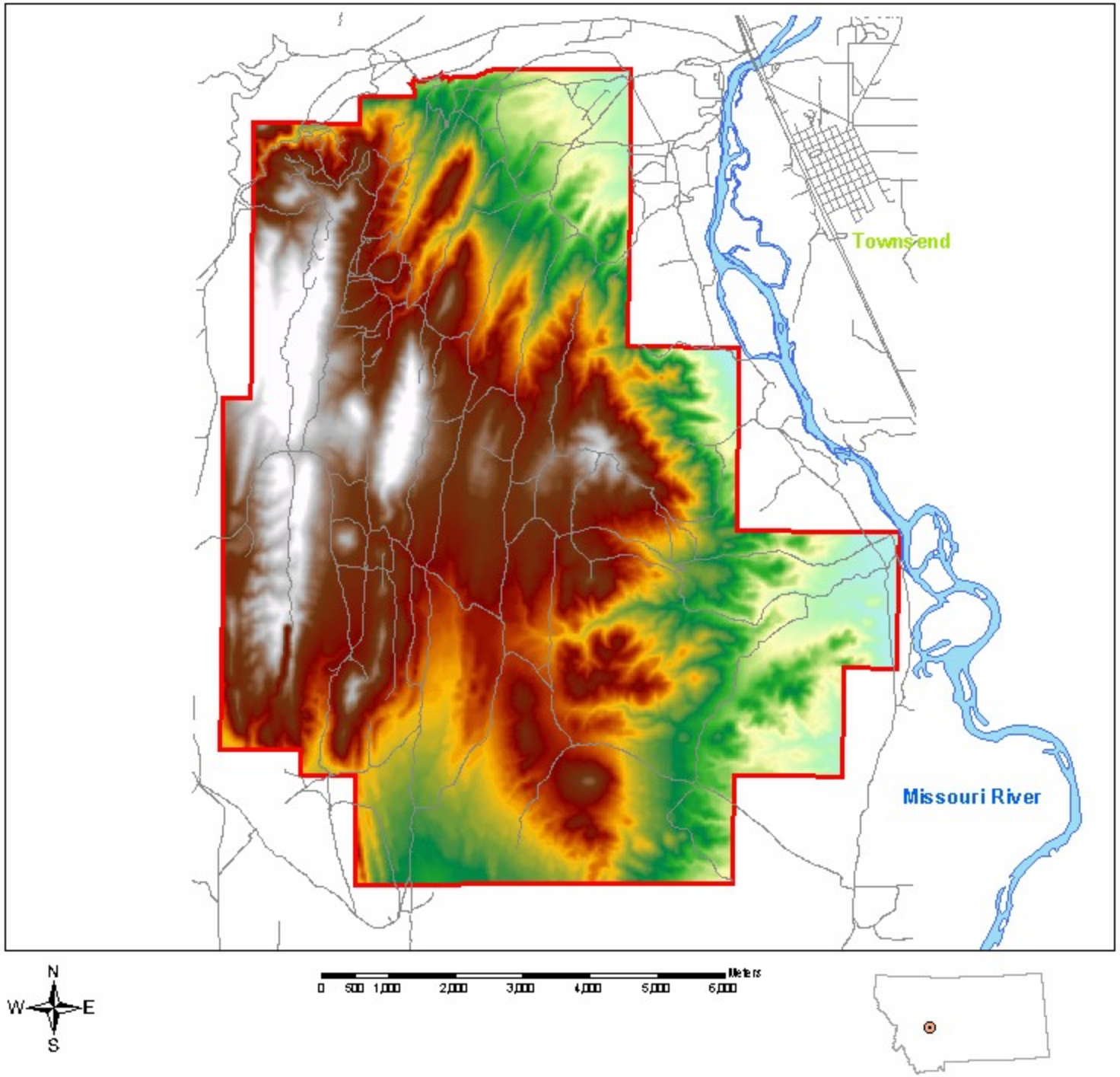
Location of Study Area

- Done by the MTARNG Environmental Office at Fort Harrison, Helena, MT
- Limestone Hills is located 30 miles southeast of Helena.


Great Falls
Missoula
90
Helena
15
Townsend
90
Bozeman
15
N
W
E
S
0
10
20
40
60
80
Miles

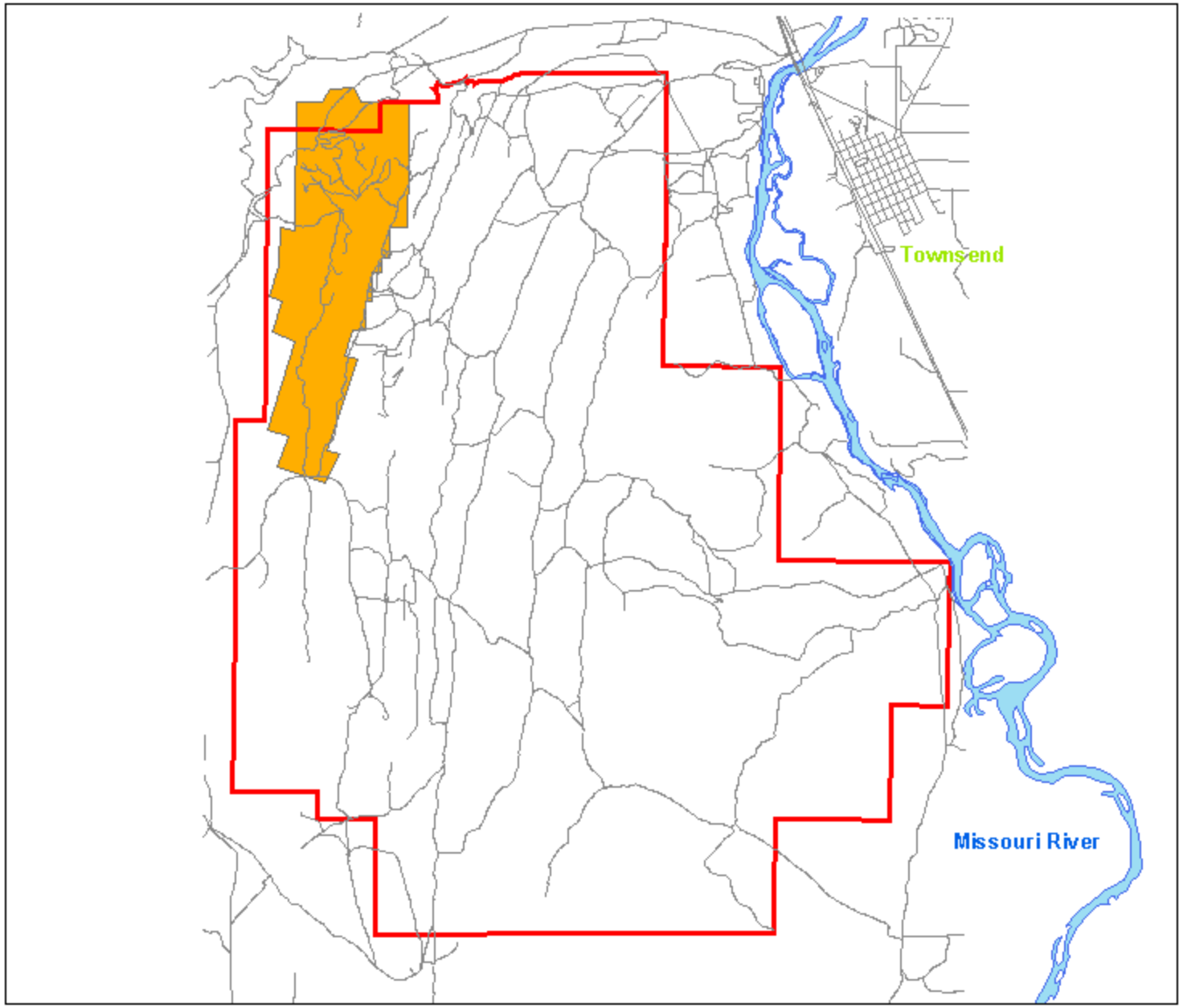
Limestone Hills Training Area

- MTARNG leases 26,000 acres of BLM land
- Graymont Western Mine operates on a 1,500 acre mine claim within Limestone Hills TA
- Capable of extracting 1000 tons of limestone per day


Townsend
Missouri River
N
W
E
S
0 500 1,000 2,000 3,000 4,000 5,000 6,000
Meters

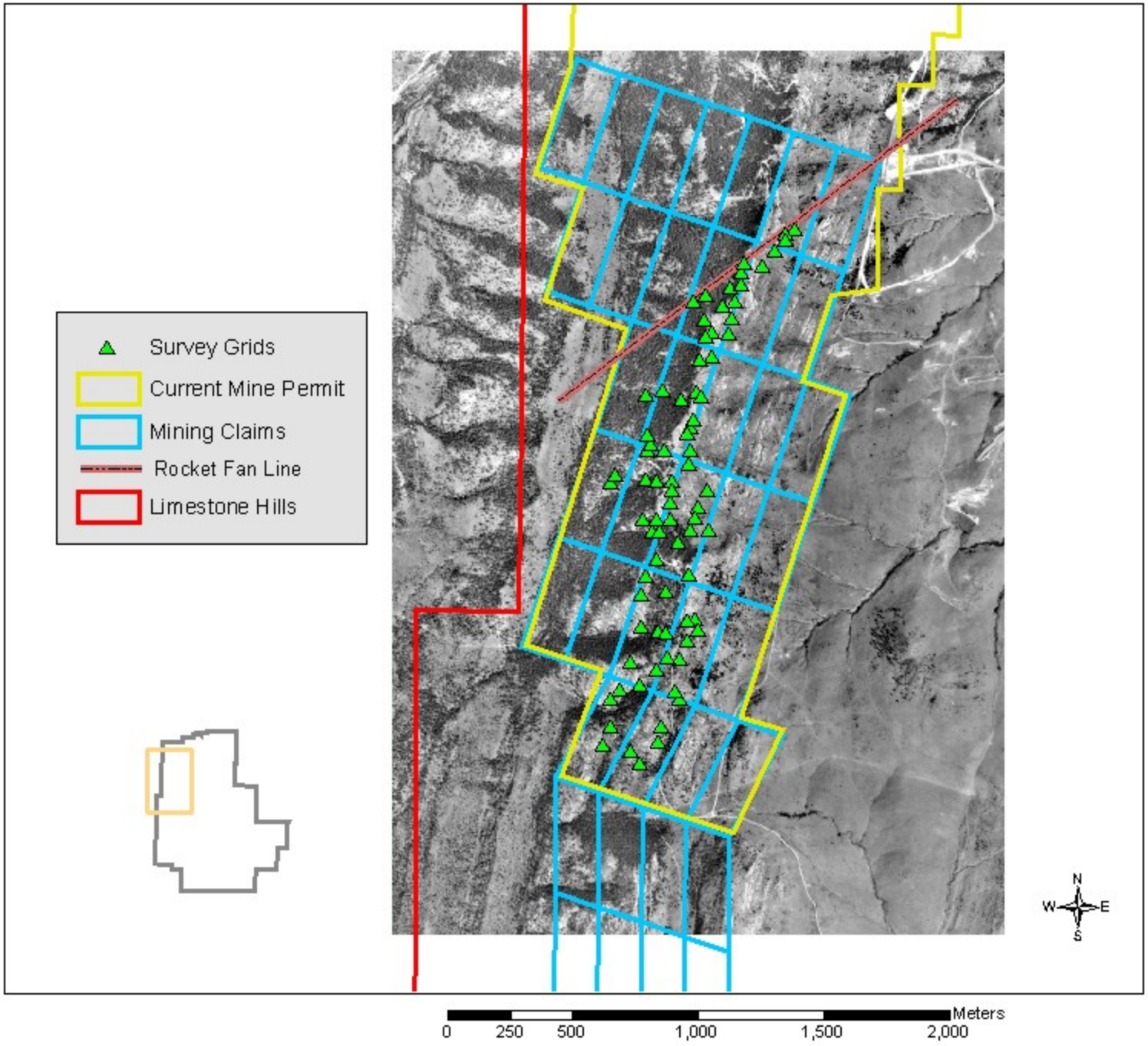
Reasons for this study

- Determine the level of approximate density, depth and distribution with respect to the proposed mine area
- Graymont Western mining expansion precluded until UXO issue is resolved
- Model the distribution of UXO
- Is it safe for the public and the environment?
- Bureau of Land Management (BLM) interests


Townsend
Missouri River
N
W
E
S
0 500 1,000 2,000 3,000 4,000 5,000 6,000
Meters

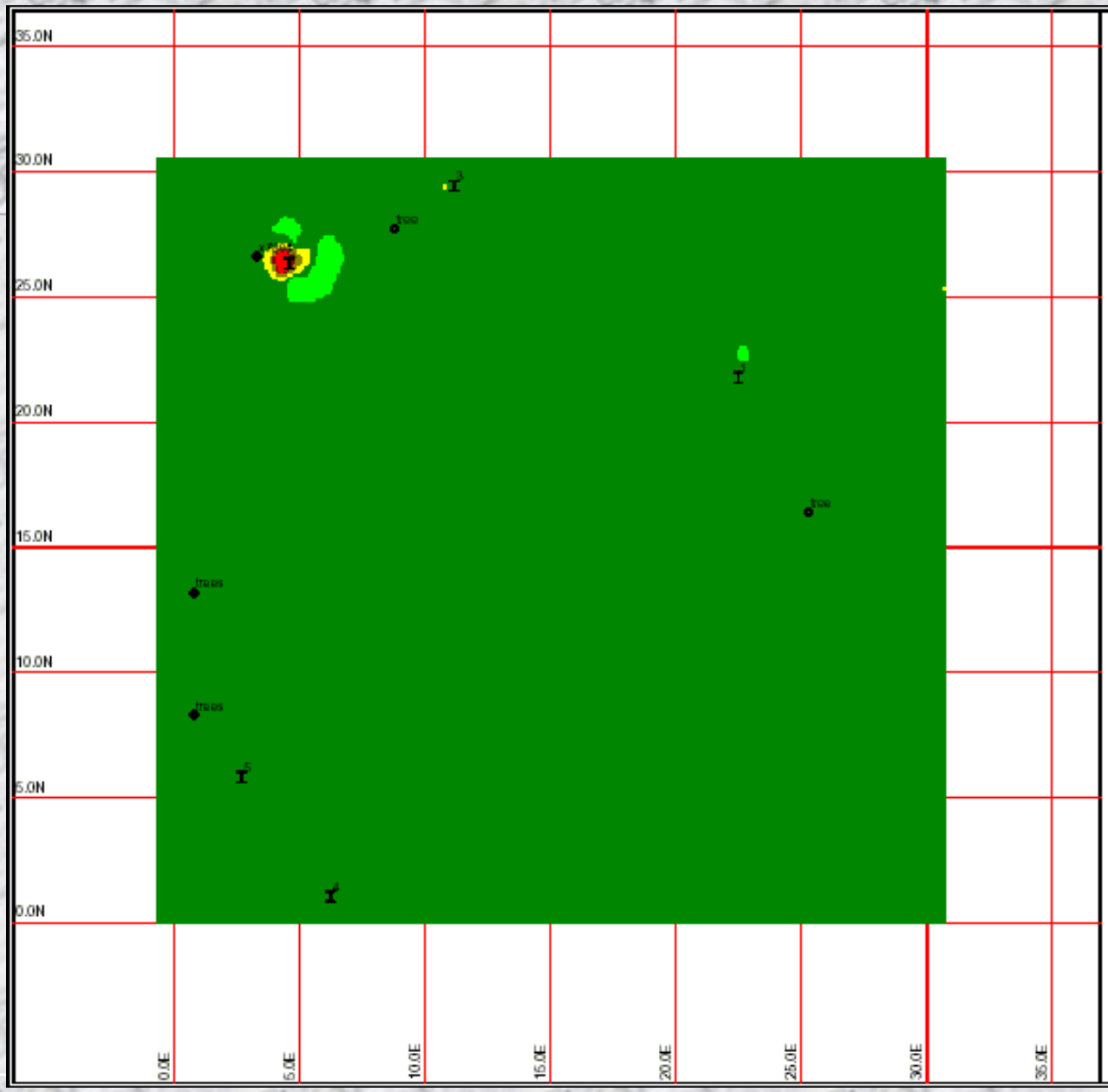
Field Methodology

- Study area: 170 acres
- Eighty seven sample grids were placed on the ridge, south of the mine
  - 30 m X 30 m grids
  - Four corners: NW, NE, SW, SE
- As of today: 40 grids have been studied and cleared


Survey Grids
Current Mine Permit
Mining Claims
Rocket Fan Line
Limestone Hills
N
W
E
S
Meters
0
250
500
1,000
1,500
2,000

Field Methodology (cont.)

- Geophysical Technology Limited (GTL) from Australia
  - Used a TM4 Vapor Magnetometer
  - Produced magnetic intensity images for each grid using GeoSoft earth sciences software.
  - Images provide the magnetic intensity of anomalies in the grid.



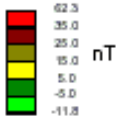
GTL

Geophysical Technology Limited
PO Box U9 UNE Armidale NSW 2351
AUSTRALIA
email: clarkpj@geotec.com.au

Instrument:	TM4 Cs Vapour Magnetometer
Sample Interval:	0.1 m
Line Interval:	0.5 m
Resolution:	0.1 nT
Operators:	P.J.Clark/L.J.Heaps
Survey Date:	Tue Jul 20 09:33:01 1999
Acq. Mode:	DISTANCE
Log File:	201a
Base File:	C:\99116~1\DATA\204\204
Data Recovery:	Magit
Data Gridding:	GEOSOFT
Grid Cell Size:	0.10m x 0.10m
Median HiPass:	Line-Length
Linear HiPass:	5m (2D)

Presentation Parameters

Data Presentation:
MagSys V5.2
Colour Assignment:
Linear
Colour Interval
10.0nT
Histogram Bins: 256
Bin Width: 0.5nT



Colour Image of
Total Magnetic Intensity

Location:	Limestone Hills, MT U.S.A
Processed for:	TTEMI
Processed by:	P.J.Clark
Project Num:	PRCE-99116
Magnetic Declination:	16.5 degrees
Map Scale:	1:200
Date Processed:	Jul 26 18:48:44 1999

Grid Id: 99-12

Field Methodology (cont.)

- For each grid:
  - Corners are GPS’d
  - Anomalies are re-acquired and data on the anomaly is recorded

Field Methodology (cont.)

- For each anomaly:
  - Analog magnetometer and an All-metals detector are used to locate the anomaly
  - Anomaly is categorized; Fragment, UXO, or Geologic Formation
  - Location is GPS'd
  - Digital photo is taken
  - Object is removed (safely) from the site.

Foerster FEREX

Radiometric Magnetometer device

Metal Detector

Vallon All-Metals detector

Field Methodology (cont.)

- Important considerations
  - Terrain is steep and rocky
  - Climate is dry and hot
  - Several pieces of equipment are needed
  - About three grids per day
  - Explosive Ordnance Disposal personnel must be present at all times
  - Limestone Hills is an active training area

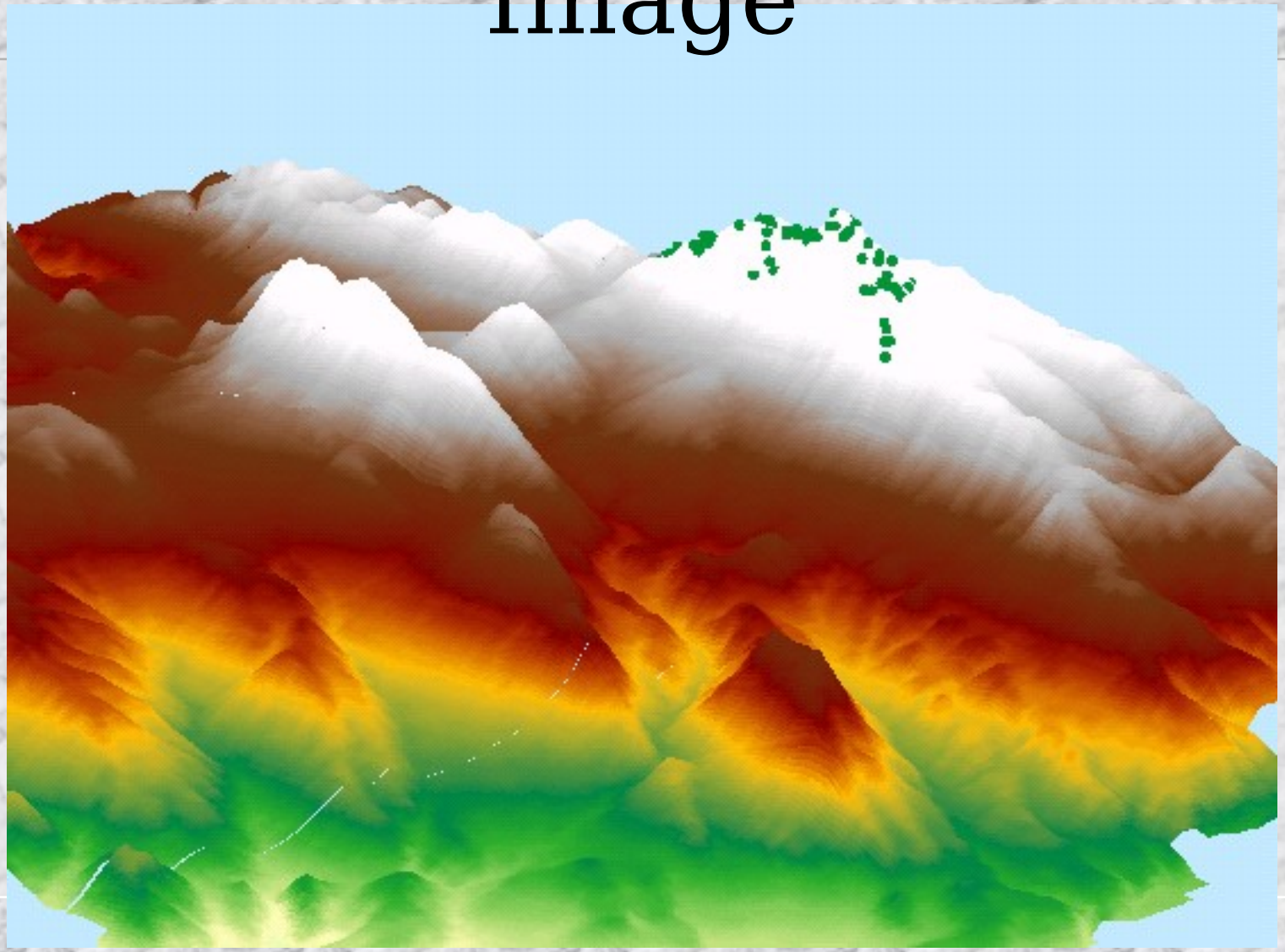
GIS Resources

- Hardware
  - Trimble ProXRS GPS
- Software
  - Pathfinder 2.7
  - ArcView 3.2
    - Extensions: Spatial Analyst, 3D Analyst
  - Migrating to ArcGIS 8.1

GIS Data Sets

- DEM
  - 15m DEM provided by CEMML
- Aerial Photography
  - Several different resolutions and acquisition dates
- Coverages and Shapefiles
  - Data sets produced by MTARNG personnel and contractors.

15m DEM ArcScene Image



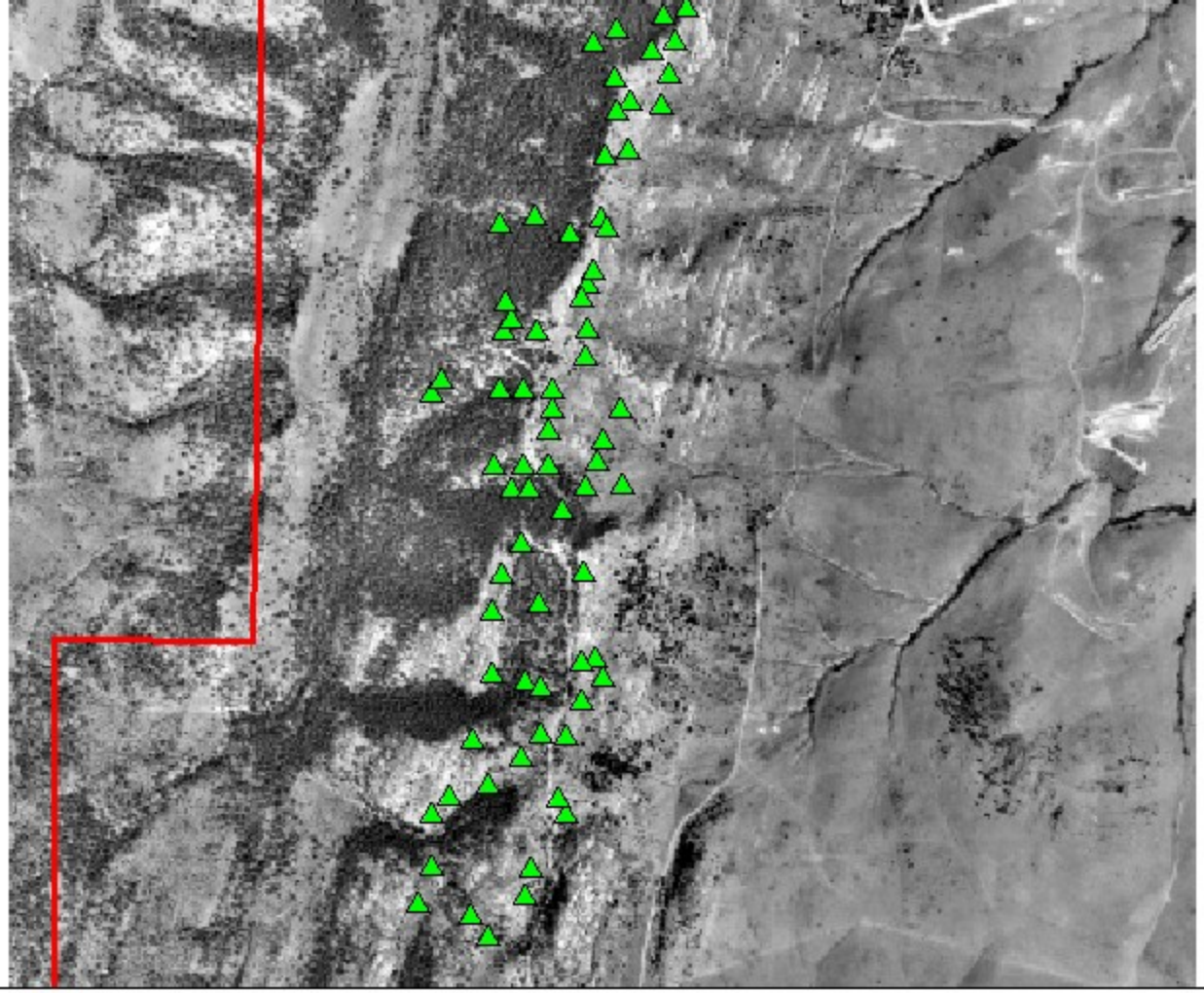
GIS Methodology

- Aerial photos:
  - First photos taken in 1991
  - 1m Resolution photos taken in 1996
  - 1 ft Resolution in 1998
  - 0.25 ft Resolution photos taken in June 2001

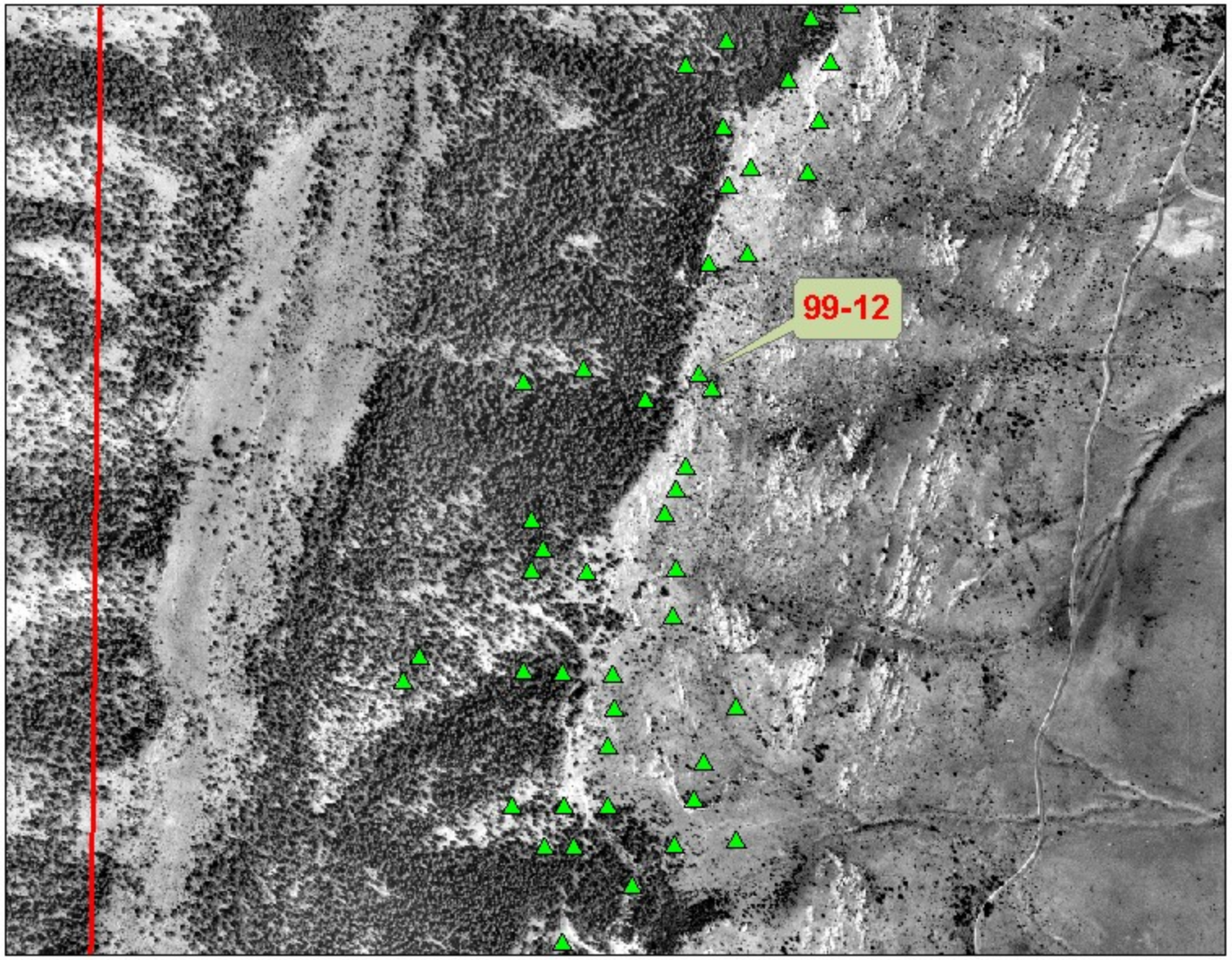
0.25 ft Resolution Photography

GIS Methodology (cont.)

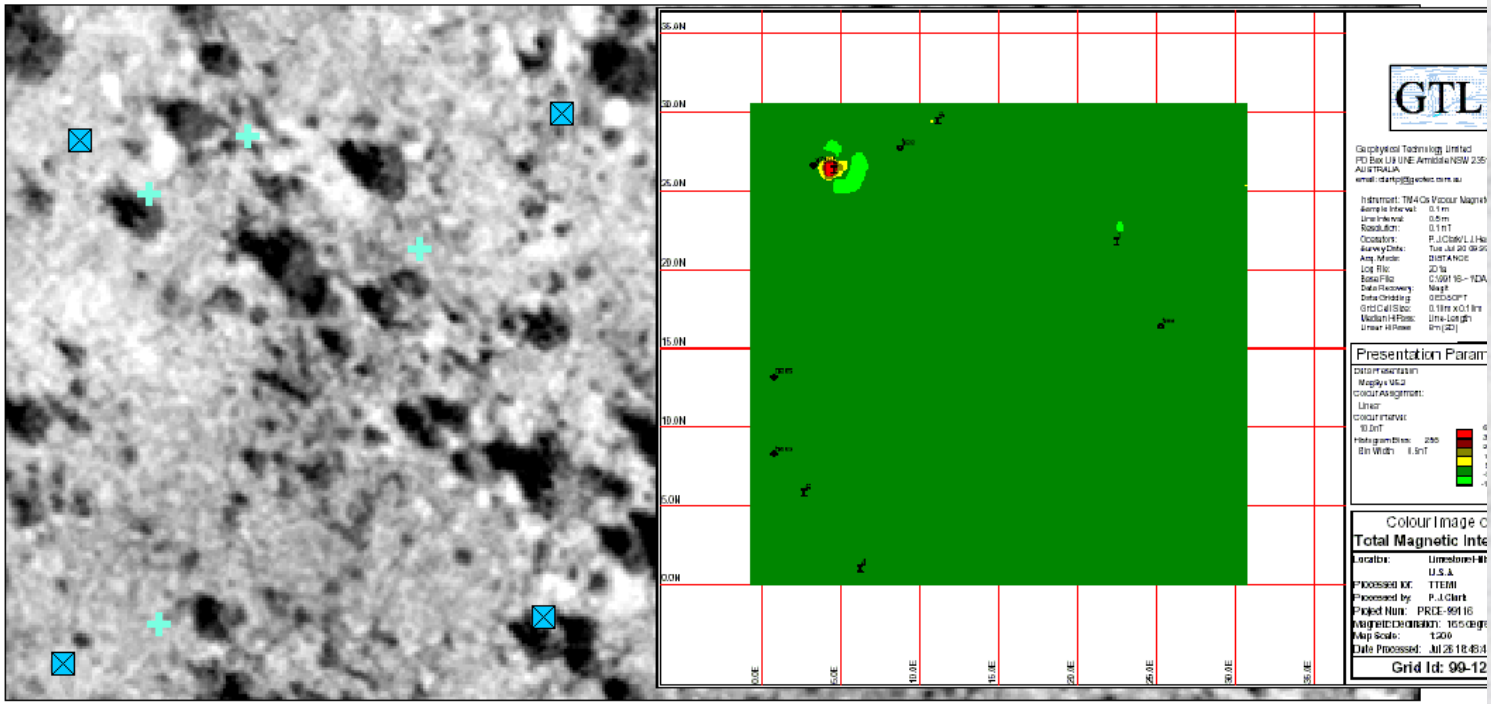
- After each day in the field
  - Download and organize GPS data
  - For each grid:
    - Link to GTL anomaly grid (.pdf)
    - Details sheet
  - For each anomaly:
    - Digital photo
    - Validation sheet



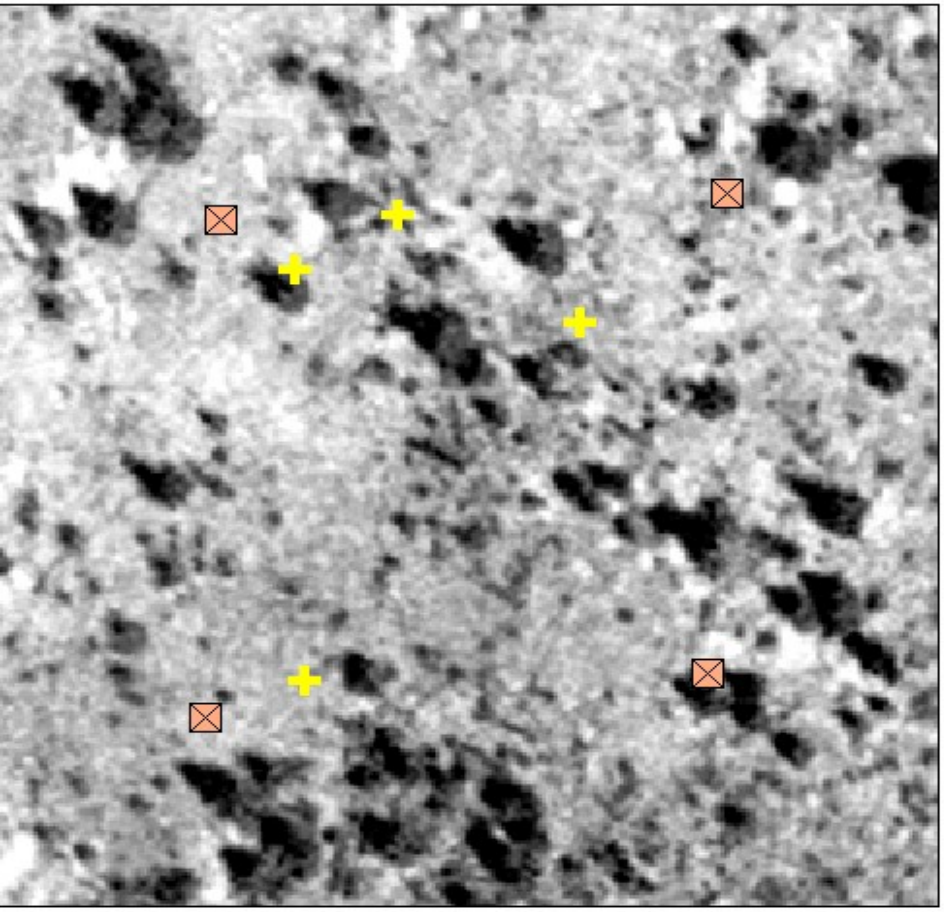
FID	Shape*	PT_NAME	X_COORD	Y_COORD	DETAILS
39	Point	99-10	452225.98566	5127384.77681	E:\itamuxo\99-10.pdf
40	Point	99-17	452018.37465	5127026.23503	E:\itamuxo\99-17.pdf
41	Point	99-15	452083.69715	5127024.9045	E:\itamuxo\99-15.pdf
42	Point	99-16	452031.64298	5127050.37301	E:\itamuxo\99-16.pdf
43	Point	99-18	452018.64065	5127085.6239	E:\itamuxo\99-18.pdf
44	Point	99-14	452152.30608	5127225.66658	E:\itamuxo\99-14.pdf
45	Point	99-12	452215.00857	5127256.02628	E:\itamuxo\99-12.pdf
46	Point	99-13	452230.17891	5127239.2866	E:\itamuxo\99-13.pdf


99-12

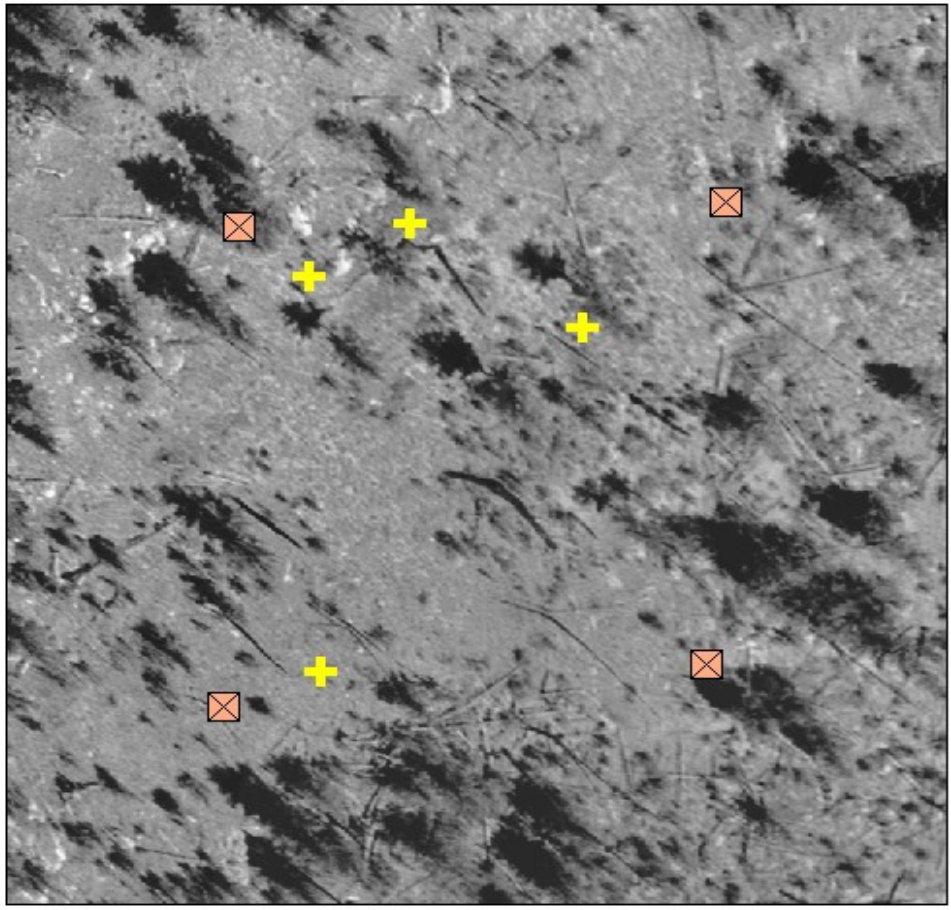
Each grid is linked to a .pdf grid showing magnetic intensity



PT_NAME	X_COORD	Y_COORD	DETAILS
99-12	452215.00857	5127256.02628	E:\itamuxo\99-12.pdf

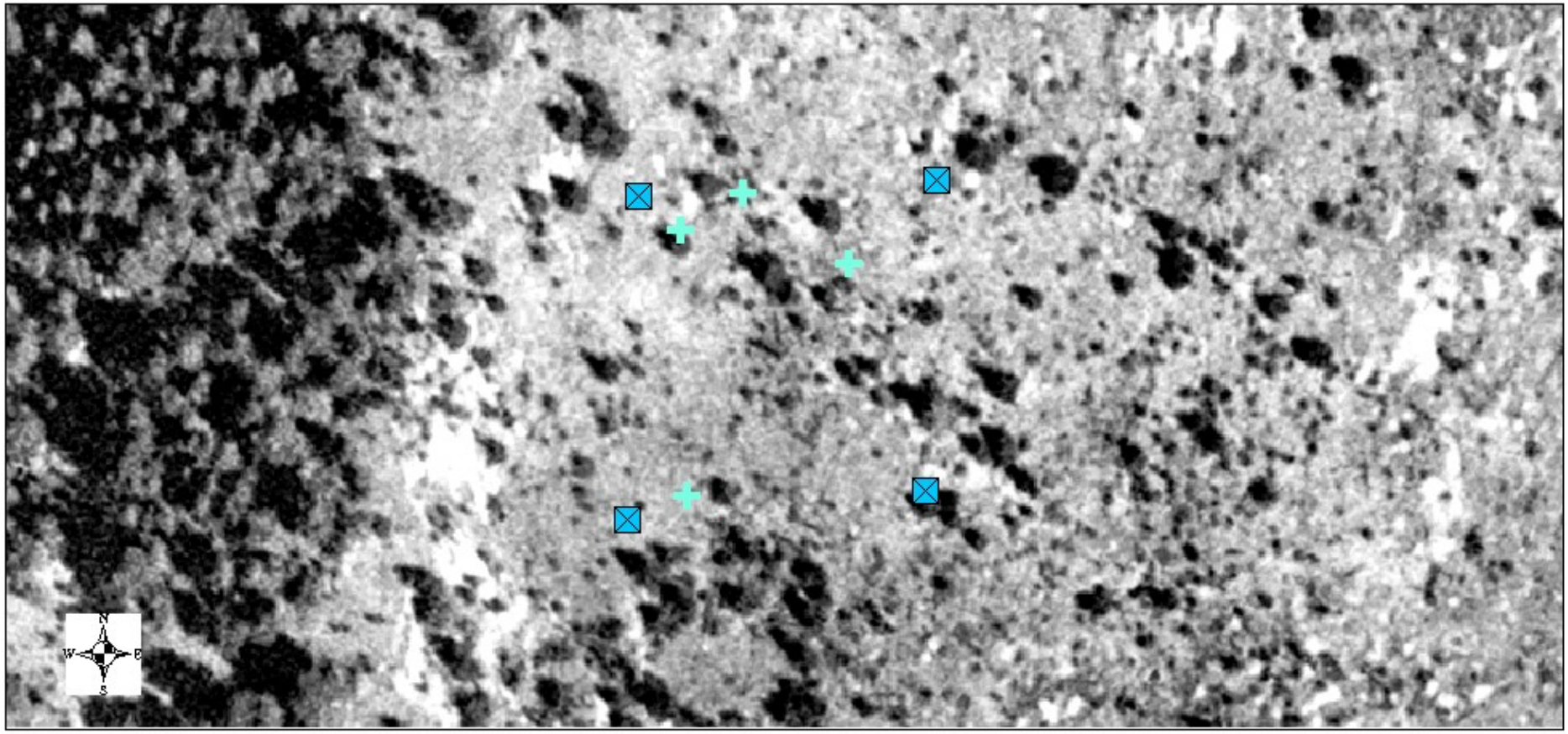


1998 1ft Resolution



2001 0.25 ft Resolution

99-12 Anomaly Locations



COMMENT	NORTHING	EASTING	ANAMOLY	DISTANCE	ORIENT	DEPTH	WIDTH	THICK	LENGTH	DETAILS
99-12 2	5127285.68	452222.625421	90mm AP	39	ne	0	0	0	0	E:\uxo\9912pt1.pdf
99-12 3	5127289.1	452228.417697	frag	44	sw	1	3	1.70	10	E:\uxo\9912pt2.pdf
99-12 1	5127282.45	452238.519083	frag	39	nw	0	3.20	1.5	10	E:\uxo\9912pt3.pdf
99-12 4	5127260.5	452223.233635	frag	41	w	10	2.70	1.20	6.80	E:\uxo\9912pt4.pdf

Each Anomaly is linked to a Validation Sheet (.pdf)

Staple Aluminum Pin Flag Here If Block 6, 7, or 8

VALIDATION WORKSHEET

EOD Team: _____ Flag/Pin No.: _____ Time: _____ Date: _____ Range/Property Owner: _____

Anomaly Visible (Circle One): On Surface Below Surface If below surface, depth to center of mass: _____ (inches) Distance from pin: _____ (inches)

sketch relative position of anomaly to pin on back of this worksheet

Identification of Anomaly (please check one and complete all associated information)

I. MILITARY

1. ( ) UXO/OEW
Type of Round: _____
Nomenclature (if known): _____

( ) Item must be photographed
- Flag/Pin Number in photo
- Attach tag to intact item

Is round fuzed? Yes No
If yes, is fuze type known? Yes No

If known, list fuze type: _____
Explosive filler (if known): _____

2. ( ) Inert Round (AP, Expended, Practice)
Type of Round: _____
Nomenclature (if known): _____

( ) Item must be photographed
- Flag/Pin Number in photo
- Attach tag to intact item

3. ( ) Large Segment of Round
Type: _____
Nomenclature (if known): _____

( ) Item must be photographed
- Flag/Pin Number in photo
- Attach tag to segment

Dimensions: Length: _____(Inches)
Width: _____(Inches)

4. Azimuth: _____ (degrees - magnetic)

Declination: _____(degrees)

5. Condition:
( ) Good condition ( ) Slightly corroded ( ) Heavily corroded
( ) Cracked open ( ) Filler leaking out ( ) Explosive residue surrounding round

6. ( ) Other Military Ordnance

(such as slap flares, smoke grenades, and spent brass)

Description:

7. ( ) Shrapnel/Fragmentation
Type (if known): _____

Dimensions: Length: _____(Inches)
Width: _____(Inches)

II. NON-MILITARY SCRAP/JUNK

8. Description:

Dimensions: Length: _____(Inches)
Width: _____(Inches)

III. NOTHING FOUND

9. ( ) If nothing is found, pin must remain in the ground with the flag. Ensure pin is secure. **( ) Backhoe needed**

Grid 99-12
Anomaly #2
90 - mm AP
5 July 2001

GRID 99-12
5 July 2001
ANOMALY #3
90mm AP

QA/QC

- Eighty grids have “emplaced” rounds.
  - Rounds planted by MTARNG; up to 5 feet below surface
  - Check accuracy of GTL magnetic imagery
  - All but three were located and correctly identified.
  - Process helps overall modeling and classification of contaminated area

QA/QC (cont.)

- GPS data acquisition:
  - Coordinates logged with GPS and hand written on validation sheets.
  - GPS has multiple users and uses at the MTARNG

QA/QC (cont.)

- Duplication of data
  - Digital and 35mm pictures taken of each anomaly
  - Backup data CD’s made often
  - Doing each grid only once was VERY important.

What’s next?

- Spatial Analyst: Model potential distribution of UXO
- High resolution photos to better map the area south of the Mine
- Process to be used in other areas contaminated with UXO
- Geographic reference to .pdf grid images

Results

- Extensive database of GPS locations, anomaly reports, and digital photos
- Model of UXO distribution
- DoD has sufficient amounts of data to base their decision.

Credits

- Clif Youmans
  - UXO Project Leader
- Linda Deahn
  - Tetra Tech EMI
- Virgil Kaiser
  - EOD-certified UXO Technician
- Montana ARNG Environmental Program

Contact Information

- Rory Ruffner
  - GIS Specialist, MTARNG Environmental Program
  - Phone: (406) 841 3086
  - Email: Rory.Ruffner@mt.ngb.army.mil